

Characterization and Comparison of Combat-Related Injuries in Women During OIF and OEF

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ABSTRACT Although historically restricted from combat roles, women suffer from combat-related injuries, especially in recent conflicts where asymmetrical warfare erases distinctions between forward and rear operating areas. U.S. service-women who sustained combat-related injury in Operation Iraqi Freedom (OIF) or Operation Enduring Freedom (OEF) between January 2003 and May 2014 were identified from the Expeditionary Medical Encounter Database. Injuries were characterized using Abbreviated Injury Scale and International Classification of Diseases, 9th Revision codes. Of the 844 combat-related injury episodes in women, 51% ($n = 433$) were OIF injuries and 49% ($n = 411$) were OEF injuries. Blast events were responsible for 90% of injuries. The average Injury Severity Score was 3, with no statistical difference in means between OIF and OEF. Of significance were increased head injuries in OEF compared with OIF (80% vs. 48%; $p < 0.001$). Although the majority of combat-related injuries suffered by women were mild, some women suffered life-threatening injuries, and nearly 65% of the injury episodes resulted in more than one injury. More research is needed as the roles of women in the military continue to expand. Future studies will investigate quality of life outcomes and gender differences in combat-related injuries.

INTRODUCTION

Military women today perform multifaceted duties working alongside men in specialties that often relate directly to combat operations and increasingly take on roles traditionally filled by male service members, such as providing unit and convoy security.¹ Even before the elimination of the direct combat exclusion rule for women in 2013, military women who served in the counterinsurgency campaigns in Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF) were frequently placed in wartime scenarios where there were no clear distinctions between the front lines of battle and the rear echelons.^{2,3} The asymmetric and irregular nature of these conflicts have generally placed military women at relatively greater risk for injury than they have faced in previous conflicts.

In addition to the increased exposure to danger associated with the ill-defined lines of combat in Iraq and Afghanistan, female military members began performing new, more hazard-

ous duties as in the U.S. Marine Corps Lioness program, which operated in Iraq, and the Marine Corps female engagement teams (FETs) in Afghanistan. The Lionesses were an all-female team formed by the Marine Corps to support a culturally sensitive approach for searching Muslim women at Iraqi checkpoints.⁴ The FETs, composed of highly motivated women Marines, began operating in Afghanistan in 2010. FETs operated from 30 different sites primarily in the Helmand province, often in areas known to be dangerous. As part of the counterinsurgency strategy adopted in Afghanistan, one of the original goals of the FETs was to meet with Afghan women in villages and discuss their concerns.⁵

Current Literature

Although women currently make up 15% of the active duty armed forces and 20% of the reserves, little research has been published to address specific injuries sustained by female military members in wartime situations. Battle injuries in recent conflicts have been characterized in sample populations primarily composed of men, as reflected in a study by Zouris et al⁶ that described injury and illness casualty distributions in OIF. Findings from this study correlated with research results from that of Dougherty et al⁷ on OIF and OEF injuries showing high incidences of extremity wounds. Data used for this sample was comprised of 665 men and only 8 women. In a more recent study on explosive events and resulting injuries, traumatic brain injury (TBI) was indicated as the most common single injury in military members who were exposed to blasts in OIF and OEF, but women were not represented in the sample.⁸

In civilian trauma, gender differences have been researched, demonstrating in some studies that women have a survival advantage over men and are less likely to develop life-threatening complications.⁹ Identifying gender differences in

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combat-related trauma victims can provide military health care providers clinical guidance that is needed to tailor individualized care, which may in turn decrease hospitalizations and improve patient outcomes.

In 2010, Trego et al¹⁰ presented a call to action for evidenced-based military women's health care to support servicewomen today. The goal of this effort is to provide a platform for establishing a military women's health research agenda. While conceptualizing a comprehensive approach to women's health and medical needs in deployed environments, it will be important to account for gender-specific health and medical requirements that encompass a wide range of physical and psychological issues, including combat-related injuries.

Research Aims

To support gender-based research efforts in the military, this descriptive study critically examined what types of combat-related injuries military women have sustained in recent conflicts, with specific attention to polytrauma incidence in this population. In addition to studying physical injury, we evaluated postinjury acute care utilization and military status as reflected by continued service in the armed forces.

METHODS

Study Population

The study sample was identified from the Expeditionary Medical Encounter Database (EMED), which is maintained by the Naval Health Research Center in San Diego, California. The EMED contains information abstracted from U.S. service members' medical records completed by military providers at forward-deployed treatment facilities in the combat zone, nearest to the point of injury. These records are linked with inpatient and outpatient medical record information and tactical, personnel, operational, and deployment-related data obtained from other U.S. Department of Defense databases.¹¹ This study was approved by the Naval Health Research Center Institutional Review Board.

Between January 2003 and May 2014, information on 835 female service personnel with 844 injury episodes related to combat operations in OIF or OEF was obtained from the EMED. For purposes of this study, dates for data collected on women injured in OIF ranged from 2003 through 2011, and dates for women injured in OEF ranged from 2007 through May 2014. All women received medical care at a forward-deployed treatment facility, had at least one documented injury, and survived the acute care period. Deployment status at the time of injury episode was confirmed using the Defense Enrollment Eligibility Reporting System (DEERS).

Measures

Individual demographics (age and branch of service), mission (OIF or OEF), and mechanism of injury were ascertained for each injury episode from the EMED. Clinical diagnosis codes

from the International Classification of Diseases, 9th Revision (ICD-9), were assigned to each injury by trained clinical staff. In addition to assignment of diagnostic codes, severity of each injury was documented with two different standardized measures: the Abbreviated Injury Scale (AIS) and the Injury Severity Score (ISS).¹² The AIS is an anatomically based injury severity scale that scores each injury on a scale from 1 (relatively minor) to 6 (untreatable) in 6 body regions (head, face, chest, abdomen, extremities, and external). The ISS, which is an overall measure of injury severity, is derived from the AIS scores of the three most severely injured body regions, with a range of 0 to 75.¹³ The ISS for each member was documented and categorized into 4 severity levels: mild (1–3), moderate (4–8), serious (9–15), and severe (≥ 16).^{14,15}

Acute care medical utilization was assessed through the Department of Defense Standard Inpatient Data Record for the episodes involving serious or severe injuries (ISS > 9) and 1 year of follow-up. Acute care hospitalizations were documented, including inpatient and intensive care unit (ICU) days within the first year after injury. Military status (active duty, active reserve, National Guard, separated) as of March 2014 was obtained from Defense Enrollment Eligibility Reporting System for female service members.

Statistical Analysis

Means and standard deviations were calculated for the continuous variables (age, ISS, injuries per episode, inpatient days, and ICU days) and comparisons between OIF and OEF were assessed with independent *t* tests. Absolute numbers and percentages were reported for categorical variables (branch of service, ISS categories, AIS body region categories, and present military status), and comparisons between OIF and OEF were assessed with χ^2 test.

Using the Barell injury diagnosis matrix, injuries sustained during explosive events were categorized by body region.¹⁶ The standard Barell matrix uses ICD-9 codes that describe trauma injuries by constructing a matrix using 12 natures of injury (fractures, dislocations, sprains and strains, internal injuries, open wounds, amputations, injuries to blood vessels, contusions and superficial injuries, crush, burns, nerves, and unspecified injuries) and either 36, 12, or 5 body regions. The majority of the matrix cells include more than one ICD-9 code. All data analyses were conducted using SAS software, version 9.3 (SAS Institute Inc., Cary, North Carolina).

RESULTS

The study population was 844 combat-related injury episodes that occurred in 835 women between January 2003 and May 2014. The injury episodes were equally distributed between OIF (51.3%) and OEF (48.7%), with the OIF episodes occurring between 2003 and 2011 and the OEF episodes between 2007 and 2014 (as shown in Table I). The mean age of the women was 26.5 years, and women injured in OEF were slightly older (27.2 years vs. 25.8 years; $p < 0.01$).

TABLE I. Demographic and Injury Characteristics by Mission 2003 to 2014 (*N* = 844 Injury Episodes)

	OIF (<i>N</i> = 433)	OEF (<i>N</i> = 411)
	Mean (SD)	
Age, Years**	25.8 (6.6)	27.2 (7.5)
ISS	3.4 (4.6)	3.2 (3.7)
Injuries per Episode	2.8 (2.7)	3.0 (2.8)
	<i>n</i> (%)	
Service Branch		
Army	367 (84.9)	367 (84.8)
Marine Corps	29 (7.1)	31 (7.2)
Air Force	28 (6.8)	28 (6.5)
Navy	5 (1.2)	7 (1.6)
ISS Category		
Mild	314 (76.4)	325 (75.1)
Moderate	67 (16.3)	56 (12.9)
Serious	23 (5.6)	39 (9.0)
Severe	7 (1.7)	13 (3.0)

ISS categories are mild (1–3), moderate (4–8), serious (9–15), and severe (≥16). ISS, Injury Severity Score; M, mean; OEF, Operation Enduring Freedom; OIF, Operation Iraqi Freedom; SD, standard deviation. ***p* < 0.01.

Study members were primarily Army personnel (84.8%), followed by Marines Corps (7.1%), Air Force (6.6%), and Navy (1.4%) service members, with no difference in the distribution between OIF and OEF. More than 90% of the injury episodes were due to blast events.

More than 90% of the injury episodes resulted in mild to moderate severity as categorized by the total ISS, with no severity difference between OIF and OEF (Table I). Although the majority of the injuries were mild to moderate, nearly 65% of the injury episodes resulted in more than 1 injury, with a mean of 2.9 injuries per episode. Despite no significant differences in injury severity between OIF and OEF, the body regions of injury were different between the two missions. The greatest percentage of injuries overall were to the head, and the percentage of head injuries was significantly higher in OEF than in OIF (80.0% vs. 48.3%; *p* < 0.001) (Fig. 1). Furthermore, in OEF, there was a higher percentage of spinal injuries (27.7% vs. 10.6% in OIF; *p* < 0.001) and a lower percentage of external injuries (2.9% vs. 8.1% in OIF; *p* < 0.01).

The Barell injury diagnosis matrix was used to categorize the ICD-9 codes by injury nature and body region to further

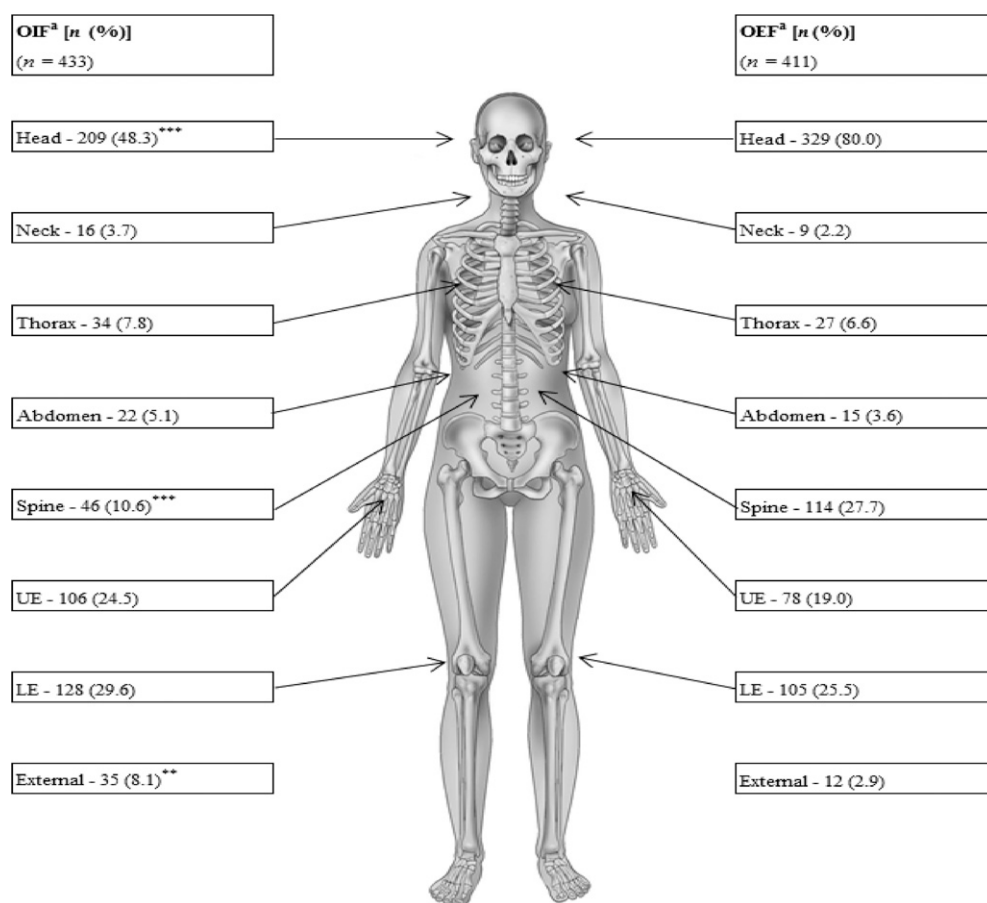


FIGURE 1. Difference in number and percentage of injuries categorized by AIS body region categories (*N* = 844 injury episodes). χ^2 comparisons are made between OIF and OEF. ^aNumber of injury episodes in each body region are not mutually exclusive. One injury episode may be represented in multiple body regions because of polytrauma. **p* ≤ 0.05; ***p* < 0.01; ****p* < 0.001.

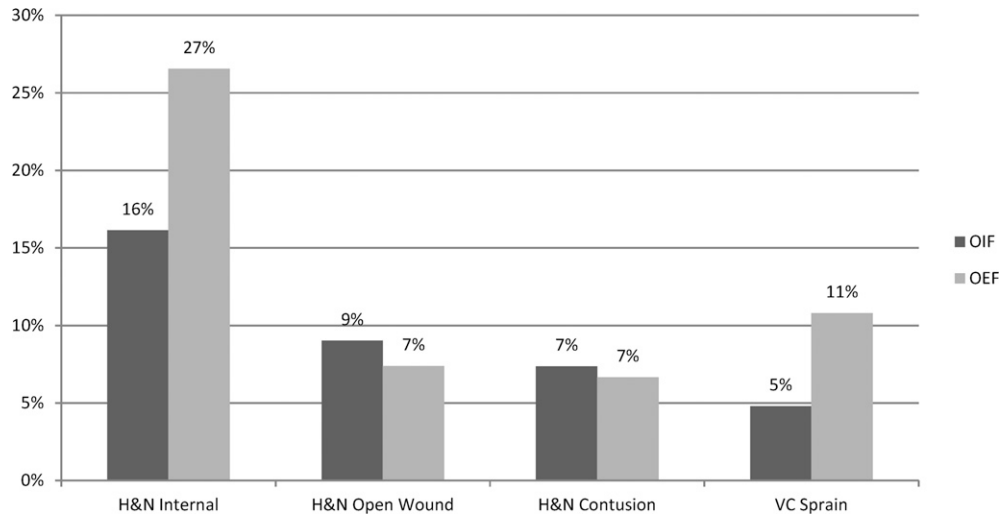


FIGURE 2. Percentage of head, neck, and vertebral column injuries, distributed by nature of injury and body region. H&N, head and neck; OEF, Operation Enduring Freedom; OIF, Operation Iraqi Freedom; VC, vertebral column.

examine differences between injuries in OIF and OEF. There was a clear increase in the percentage of head and neck internal injuries, primarily concussions, in OEF (vs. OIF) as well as an increase in vertebral column strains in OEF (Fig. 2). In contrast, open wounds and burns of the upper and lower extremities were more common in OIF than in OEF (Fig. 3).

The examination of follow-up data included acute care utilization within the first year after injury and military status as of March 2014. Of the 82 servicewomen who sustained

serious and severe injuries (ISS > 9) during 1 year follow-up, most ($n = 78$; 95%) required acute care hospitalization, with up to 6 separate hospitalizations and an average of 32 inpatient days (median 19 days; Fig. 4). In addition, 35 of the 82 casualties (43%) required at least 1 ICU admission, with an average of 5 ICU inpatient days (median 2 days). Of the servicewomen injured before January 1, 2014, 78.0% remained on active status (active duty, active reserve, National Guard), 67.1% on active status from OIF and 89.9% from OEF (Table II). In both OIF and OEF, injury severity was related

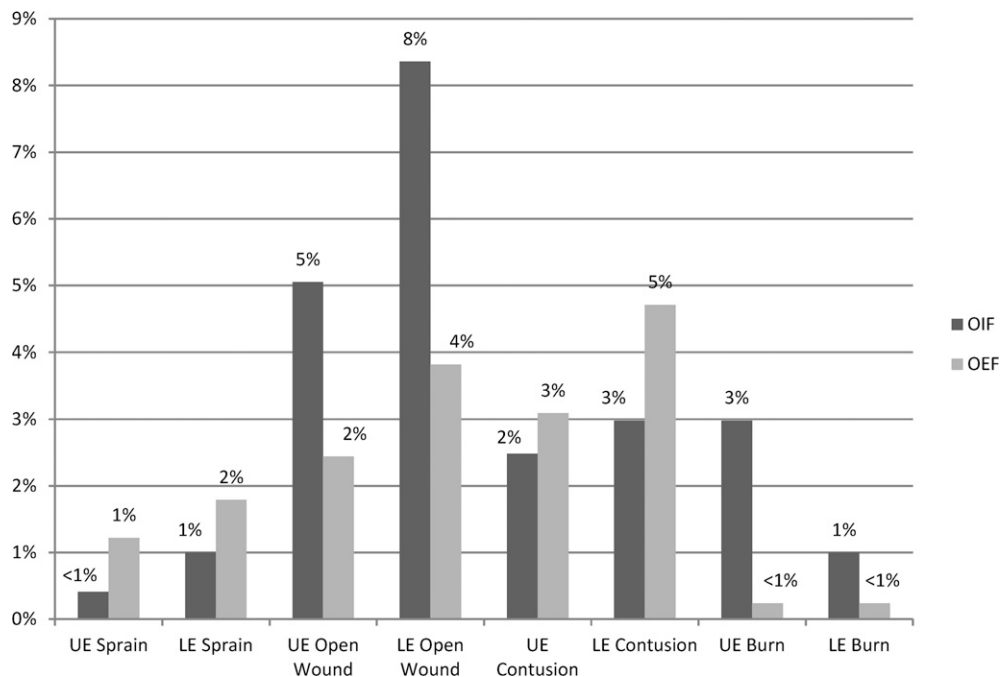


FIGURE 3. Percentage of extremity injuries, distributed by nature of injury and body region. LE, lower extremity; OEF, Operation Enduring Freedom; OIF, Operation Iraqi Freedom; UE, upper extremity.

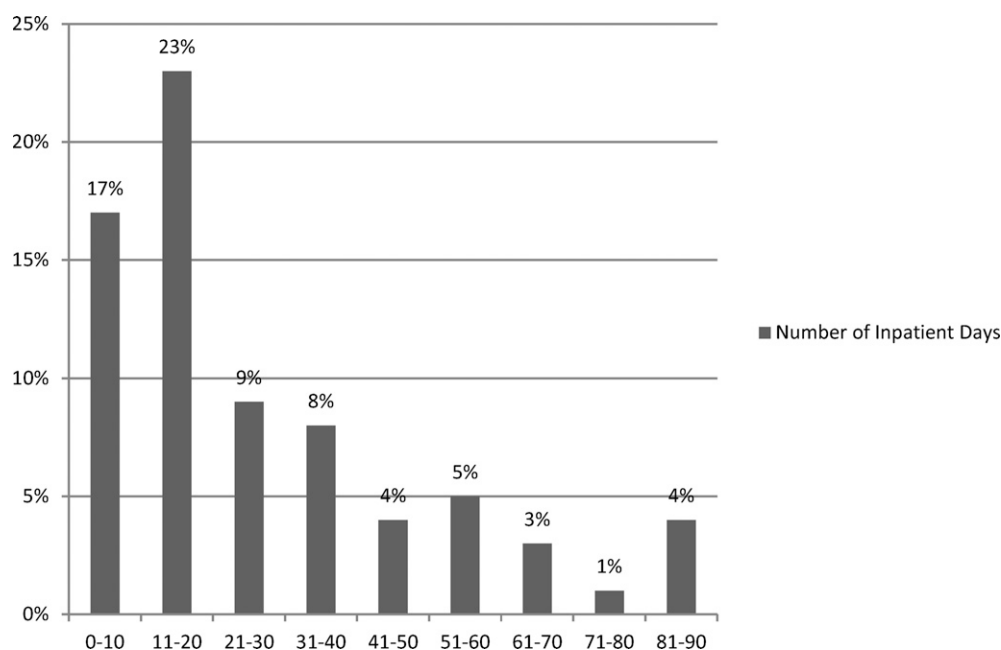


FIGURE 4. Number of inpatient days within the first year after the injury for injured servicewomen, ISS >9.

to active status; the percentage of women who remained on active military status decreased as injury severity increased.

DISCUSSION

The primary aim of this study was to characterize combat injuries in women during OIF and OEF, so we feel that the population of 835 women in this study provides a strong representation of the clinical profile for military women injured in combat during the conflicts in Iraq and Afghanistan. The results show that the majority (>90%) of combat-related injuries suffered by female service members were mild to moderate, with an average ISS of 3.3 and no notable differ-

ence between OIF and OEF. These findings correspond with male blast injury data from these same conflicts, in which the average ISS was 4.5 and more than 85% of injury episodes were also in the mild to moderate severity range.⁸

Service women's injury profiles differed slightly between OIF and OEF. Head and back injuries were more common in OEF. This difference is most likely explained by the rise in mounted blast events in OEF, which resulted in more vertebral column injuries as well as more mild traumatic brain injuries (MTBIs) sustained by exposure to the concussive effects of the blasts. Higher overall head injury rates reported in OEF might also be attributable in part to increases in operational tempo as well as the implementation of population-based screening measures.¹⁷ The increased amount of external injuries observed among female service members in OIF, although not greatly more by actual numbers, was significant. This may be related to unfortunate events in Iraq where several U.S. servicewomen were burned while traveling in vehicles that were involved in explosive events.¹⁸

Polytrauma was evident in the majority of women injured in these conflicts; findings showed that almost 65% of injury episodes had more than one injury. We noted that the mean acute care length of stay (LOS) was 32 days in women who sustained serious or severe injuries (ISS 9). In civilian patient data collected from the Pennsylvania Trauma Outcome Study, an average LOS of 4.76 days was reported in patients without complications, and a mean LOS of up to 16 days was reported in trauma patients with complications.¹⁹ Findings from the Pennsylvania Trauma Outcome Study were not broken out by gender. The increased LOS in the military population can be partially explained by the complicated route of evacuation that occurs when a patient is transferred back to

TABLE II. Military Status as of March 2014 by Operation 2003 to 2013 (N = 824)

	OIF (N = 429)	OEF (N = 395)
	n (%)	
Total Active Military Status***	288 (67.1)	355 (89.9)
Active Duty	116 (27.0)	224 (56.7)
Active Reserve	112 (26.1)	85 (21.5)
National Guard	60 (14.0)	46 (11.6)
Separated	141 (32.9)	40 (10.1)
Total Active Status by ISS Category***		
Mild	241 (74.6)	278 (92.7)
Moderate	27 (49.1)	58 (89.2)
Serious	17 (43.6)	15 (65.2)
Severe	3 (25.0)	4 (57.1)

ISS categories are mild (1–3), moderate (4–8), serious (9–15), and severe (≥16). Total active military status includes active duty, active reserve, and National Guard. ISS, Injury Severity Score; OEF, Operation Enduring Freedom; OIF, Operation Iraqi Freedom. ****p* < 0.001.

a U.S. facility from the combat zone, which may add several inpatient days as a patient awaits medical transport. The finding of extended LOS in military women who have suffered traumatic injuries compared with the civilian trauma population is important, especially given that fiscal concerns related to military health care utilization cannot be ignored.

Head injuries were the most prevalent injuries identified in the study. This is consistent with data found in the Defense Medical Epidemiology Database (DMED), which contains summarized medical event data gathered from the military services and Department of Defense worldwide. (DMED was originally supported by the Defense Women's Health Research Program to evaluate the health of active duty service members, with a particular emphasis on women.) Findings from the DMED show that among military women, the rate of outpatient head injury diagnosis nearly doubled between 2003 and 2012.²⁰ However, few military medical studies have specifically considered effects of TBI on women. Questions about how TBI might specifically affect military women should be recognized as a knowledge gap in military medicine. Servicewomen's response, recovery, and reintegration patterns may help to inform our understanding of military TBI in general, and could advance development of effective treatment strategies for all service members, veterans, their families, and civilians.

Even though most military TBIs (82%) are classified as MTBIs and most MTBI patients recover within several weeks, 30 to 40% will develop physical, cognitive, or emotional symptoms that persist beyond 3 months postinjury.^{21–24} Findings of several studies suggest that women may be somewhat more likely to develop persistent/chronic effects of TBI.^{24–28} Department of Veterans Affairs researchers who have studied large numbers of service members with deployment-related TBI have observed that female veterans are more likely to report severe somatosensory, cognitive, and vestibular symptoms²⁹; that being female is one of several variables predicting multisensory (auditory, visual, vestibular) impairment³⁰; and that many neurobehavioral sequelae, including somatosensory and vestibular dysfunction, are especially common among female veterans diagnosed with TBI.³¹ However, further research is needed to disentangle contributing factors, such as age, willingness to seek medical care, prior head injury, and comorbidities, that are known to complicate TBI recovery. A study of OEF/OIF service members found that, after controlling for a higher prevalence of post-traumatic stress disorder (PTSD) among women, post-traumatic stress disorder was the strongest predictor of chronic post-TBI symptoms, which were comparable in prevalence for male and female veterans.³²

The need to better understand how TBI affects women has implications for general TBI treatment. Although precise underlying mechanisms are not yet fully understood, there is a growing body of evidence that suggests endogenous female hormones—estrogen and/or progesterone—can exert neuroprotective effects by promoting brain cell survival through antioxidant, anti-inflammatory, and antiapoptotic effects, thereby mitigating neurodegenerative processes associated with

brain injury (TBI, stroke) and brain disease (Parkinson's disease, Alzheimer's disease, amyotrophic lateral sclerosis). With respect to TBI, it has been proposed that progesterone helps to stabilize and protect cell membranes against lipid peroxidation.^{33,34} Several preclinical studies and human studies have reported promising findings concerning the use of exogenous estrogen, progestin, and progesterone as possible treatments for patients with TBI, irrespective of gender. Reported beneficial effects include reduced cerebral edema and reduced intracranial pressure.^{35–40}

Study Limitations

The primary limitation of this study is that women who were killed in action or died of wounds were not included in the analysis. This is important because the types of wounds and wounding patterns of combat-related deaths are known to be different from combat-related injury survivors.⁴¹ At the time of this publication, the Defense Manpower Data Center reports 160 female deaths during operations in Iraq and Afghanistan.⁴²

Another limitation of this study is that it relies on ICD-9 and AIS coding taxonomies, which have been developed for and normalized on civilian trauma. This may limit the ability to adequately characterize injuries typically seen only in combat, such as massive soft-tissue defects, cranial avulsions, noncompressible junctional vessel injuries, and burns in body regions that may be specific to combat injuries.⁷

CONCLUSION

With the elimination of the direct combat exclusion rule for women, mission responsibilities of women will continue to change and bring increased physical and mental risks related to combat assignments. This raises the question of whether or not gender differences exist in battle injured service members and also emphasizes the need to study combat injuries that are not exclusive to women, but may affect military women and their health outcomes in unique ways. New and continued research in this area can inform the advancement of military medicine by identifying interventions and remedies of potential benefit to all service members. Future studies will address differences between battle-injured and nonbattle-injured women compared with a matched male cohort, as well as gender differences in mental health and long-term quality of life outcomes.

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Judy L. Dye holds the rank of Captain in the U.S. Navy Nurse Corps Reserve.

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